HEWLETT-PACKARD

460BR

FAST PULSE AMPLIFIER

OPERATING AND SERVICING MANUAL

OPERATING AND SERVICING MANUAL

FOR

MODEL 460BR

FAST PULSE AMPLIFIER

Serial 1720 and Above

HEWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

460B004-3

SPECIFICATIONS

Frequency Response:	High Frequency - closely matches Gaussian curve when operating into a 200-ohm resistive load. 3 db point is 120 mc. Low Frequency - off approx. 3 db at 100 kc when operating into a matched load. Off approx. 3 db at 3 kc when operating into an open circuit (i.e., CRT plates) or succeeding amplifier. With hp 410B VTVM - when used with hp 46A-95D Adapter, response ±1 db, 200 kc to 200 mc.
Gain:	Approximately 15 db into 200 ohm load.
Output Impedance:	Approximately 200 ohms.
Rated Output:	Linear Amplifier - Approximately 8 volts peak into a 200 ohm load or 16 volts peak into open circuit.
Maximum Output:	Pulse Amplifier - Approximately 125 volts negative peak open circuit (unilateral) pulse operation 10% duty cycle.
Input Impedance:	200 ohms (+8 volts input required for 125 volts output).
Noise Figure:	Less than 6 db.
Delay Characteristics:	Approximately .016 μsec.
Rise Time:	Approximately 0.003 μsec. No appreciable overshoot.
Power Supply:	115/230 volts ± 10%, 50/1000 cps, 50 watts.
Size:	19" relay rack panel, 5-1/4" high; 6-3/4"deep.
Weight:	12 lbs. Shipping weight 18 lbs.
Accessories Available:	hp 46A-16A Patch Cord: 200 ohms, 2' long. hp 46A-16B Patch Cord: 200 ohms, 6' long. hp 46A-95A Panel Jack: For 200 ohm cables low capacitance. hp 46A-95B Cable Plug: For 200 ohm systems. hp 812-52 Cable: 200 ohm cable in length to specification. hp 46A-95C 50-ohm Adapter: Type N to hp 460, 50 ohm termination. hp 46A-95D Adapter: hp 410B VTVM to hp 460, no termination. hp 46A-95E Connector Sleeve: Joins two 46A-95B Cable Plugs. hp 46A-95F Adapter: For connecting to 5XP CRT. hp 46A-95H Adapter: Type N to hp 460, 200-ohm termination. hp 46A-95J Adapter: Type N to hp 460, no termination. hp 46A-95K Adapter: hp 410 VTVM to hp 460, 200 ohm termination. hp 460B-95A Adapter: For connecting to hp Model 150A Oscilloscope plates.

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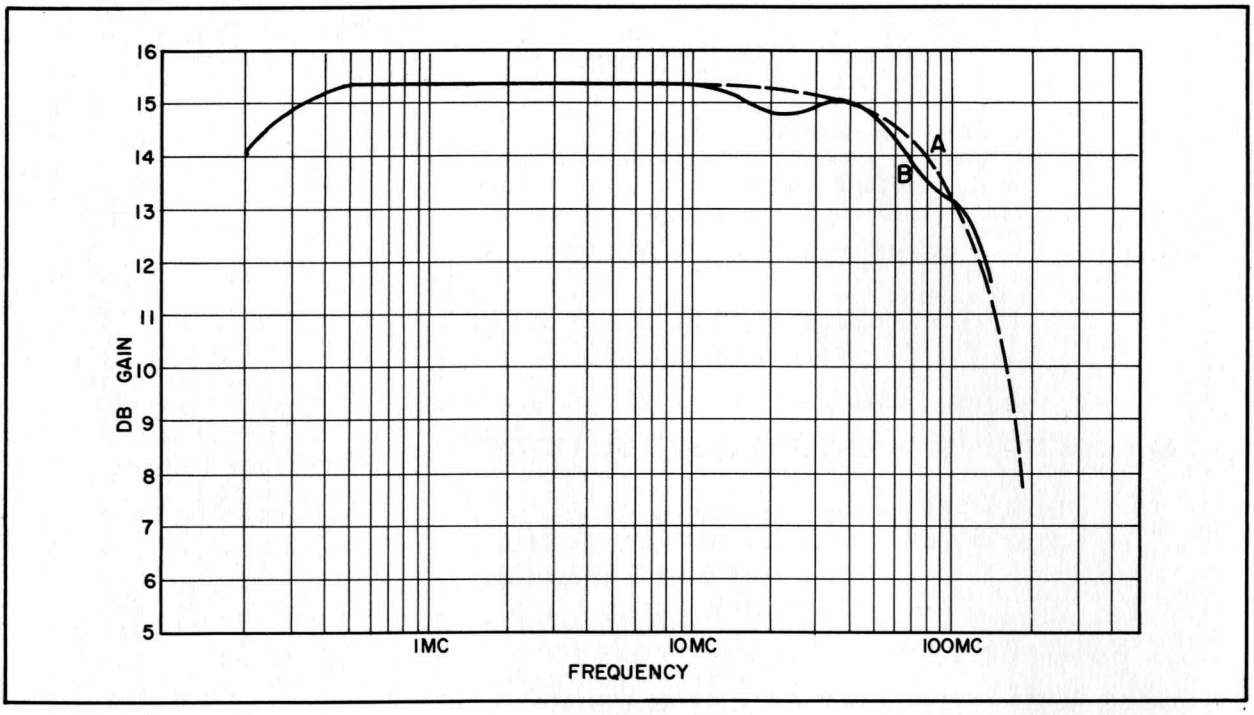

Figure 1. (A) Gaussian Response
(B) Typical 460BR Amplifier Response

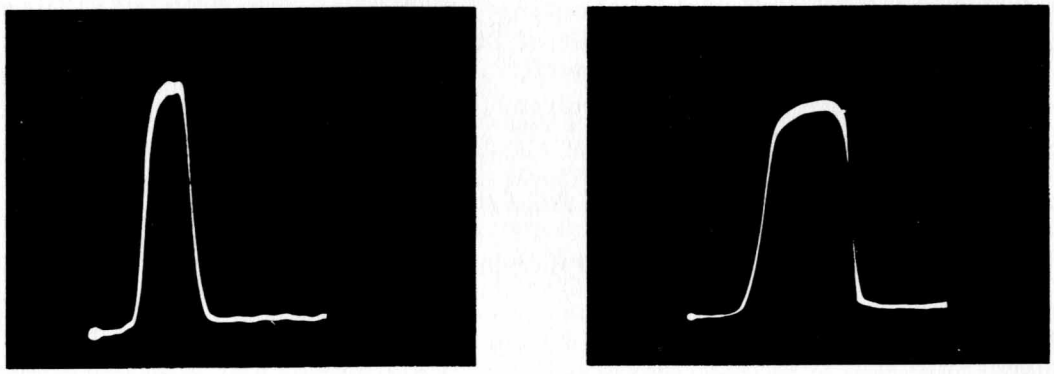

Figure 2. (A) 0.01 μsec Pulse Through hp 460BR Amplifier
(B) 0.02 μsec Pulse Through 3 Amplifiers in Cascade

SECTION I

GENERAL DESCRIPTION

1-1 DESCRIPTION

The hp Model 460B is a wide band distributed amplifier especially designed to amplify high speed pulses to high voltage levels with negligible overshoot. The output voltage is sufficiently high to drive the deflection plates of a cathode ray-tube. In order to retain the fast rise time and shape of high speed pulses, it is necessary that the amplifier have a wide, reasonably flat frequency response. The frequency response of the hp Model 460B closely approximates the gaussian response and hence retains the characteristics of short fast pulses. Figure 1, Figure 2.

The high output of the 460B is obtained with standard receiving tubes by designing the amplifier primarily to amplify pulses of a single polarity. Thus the Model 460B amplifies positive pulses to the maximum level of 125 volts open circuit, while negative pulses may be amplified to a maximum level of 16 volts open circuit. A phase inversion occurs within the amplifier so that a positive pulse applied to the input will be a negative pulse at the output. However, either upward or downward deflections of the CRT is possible, since either the upper or lower deflection plate may be connected to the ground terminal of the Model 460B.

1-2 ACCESSORIES AVAILABLE

A complete line of accessories, for use with the Model 460B, is available from the Hewlett-Packard Company. These accessories are listed on the Specification page and at the end of the Table of Replaceable Parts, Section V.

1-3 230 VOLT OPERATION

This instrument is normally supplied with the power transformer connected for 115 volt operation, unless otherwise specified on the order. Complete conversion information for 230 volt operation is contained in Section IV of this manual.

SECTION II

OPERATING INSTRUCTIONS

2-1 INSPECTION

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received.

After the instrument is unpacked, it should be carefully inspected for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this instruction manual.

2-2 INSTALLATION

No special precautions are necessary except, when several 460 Amplifiers are to be used in cascade, they must have a good common ground, i.e.: mounted in a relay rack, and the high-voltage output must be kept away from the input to avoid the possibility of feedback.

2-3 CONTROLS AND TERMINALS

ON

This toggle switch controls the a-c power supplied to the instrument from the power line.

LINEAR, PULSE

This rotary switch selects the type of amplification desired.

FUSE

The fuseholder, located on the panel, contains the power line fuse. Replacement fuses should be of the type specified in the Table of Replaceable Parts, Section V.

POWER CABLE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector. The third contact is an offset, round pin added to a standard two-blade connector which grounds the instrument chassis when used

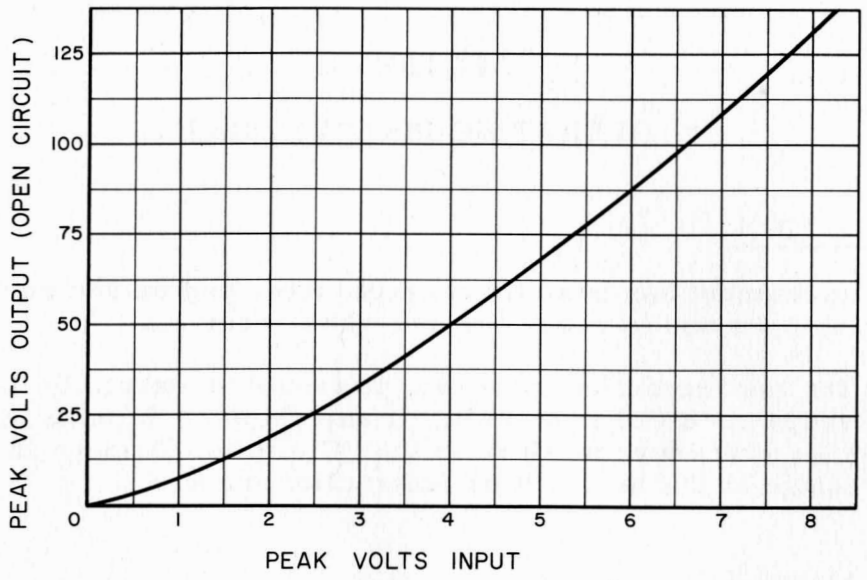

Figure 3. Linearity Characteristics of 460BR Amplifier

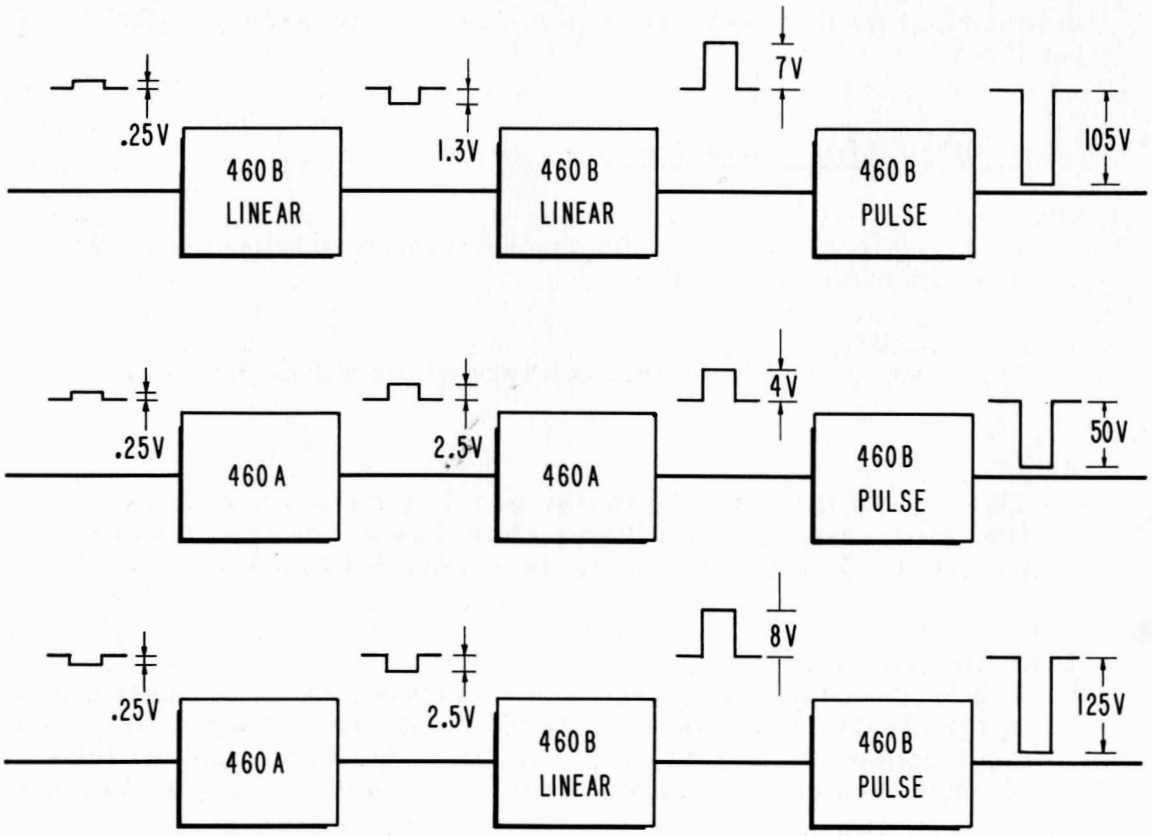

Figure 4. Cascading 460 Amplifiers

with an appropriate receptacle. An adapter may be used to connect this plug to a standard two contact system. When the adapter is used, the ground connection is brought out on a short wire. This ground lead should then be connected to a suitable ground for the protection of operating personnel.

INPUT AND OUTPUT

The input and output jacks on the control panel, require special 200-ohm connectors and cables. (See paragraph 1-2).

2-4 OPERATION

Connect the Model 460B to the power line, turn on the power switch and the instrument is in operation.

To use as a linear amplifier to amplify sine waves, etc., or pulses of either polarity, set the LINEAR-PULSE switch to the LINEAR position. When the LINEAR-PULSE switch is in this position the output is limited to 16 volts peak into an open circuit or 8 volts peak into a 200-ohm load. It must be remembered that a phase reversal between input and output is present and that a positive input pulse appears in the output as a negative pulse.

To realize the full output capabilities of the Model 460B, the LINEAR-PULSE switch must be in the PULSE position and a positive pulse of about 8 volts peak be supplied to the input.

In the PULSE position of the LINEAR-PULSE switch the amplifier tubes are operated at higher than normal supply voltages. The grid bias is increased to keep tube dissipation within ratings. Under these conditions (+8 volt input) the rated tube dissipation is reached with a duty cycle of 10%. Lower driving voltages will allow proportionally higher duty cycles, but the output voltage will be lower. See Figure 3.

In order to supply this 8-volt positive pulse to a Model 460B, the units may be cascaded or used with one or more Model 460A Wide Band Amplifiers, see Figure 4. In general, when cascading 460 amplifiers, consideration must be given to the polarity as well as the amplitude of the pulse to be amplified. For maximum deflection, the set-up must be arranged so that the input to the last 460BR amplifier is positive and of approximately 8 volts peak amplitude. This is easily done because the 460BR inverts the input pulse. Hence, an additional 460B can be used when necessary to invert pulse polarity. In most applications an input of about 4 volts is sufficient to give satisfactory deflection of a cathode-ray tube. Certain precautions must be taken when cascading several 460 Amplifiers, see Paragraph 2-2, INSTALLATION.

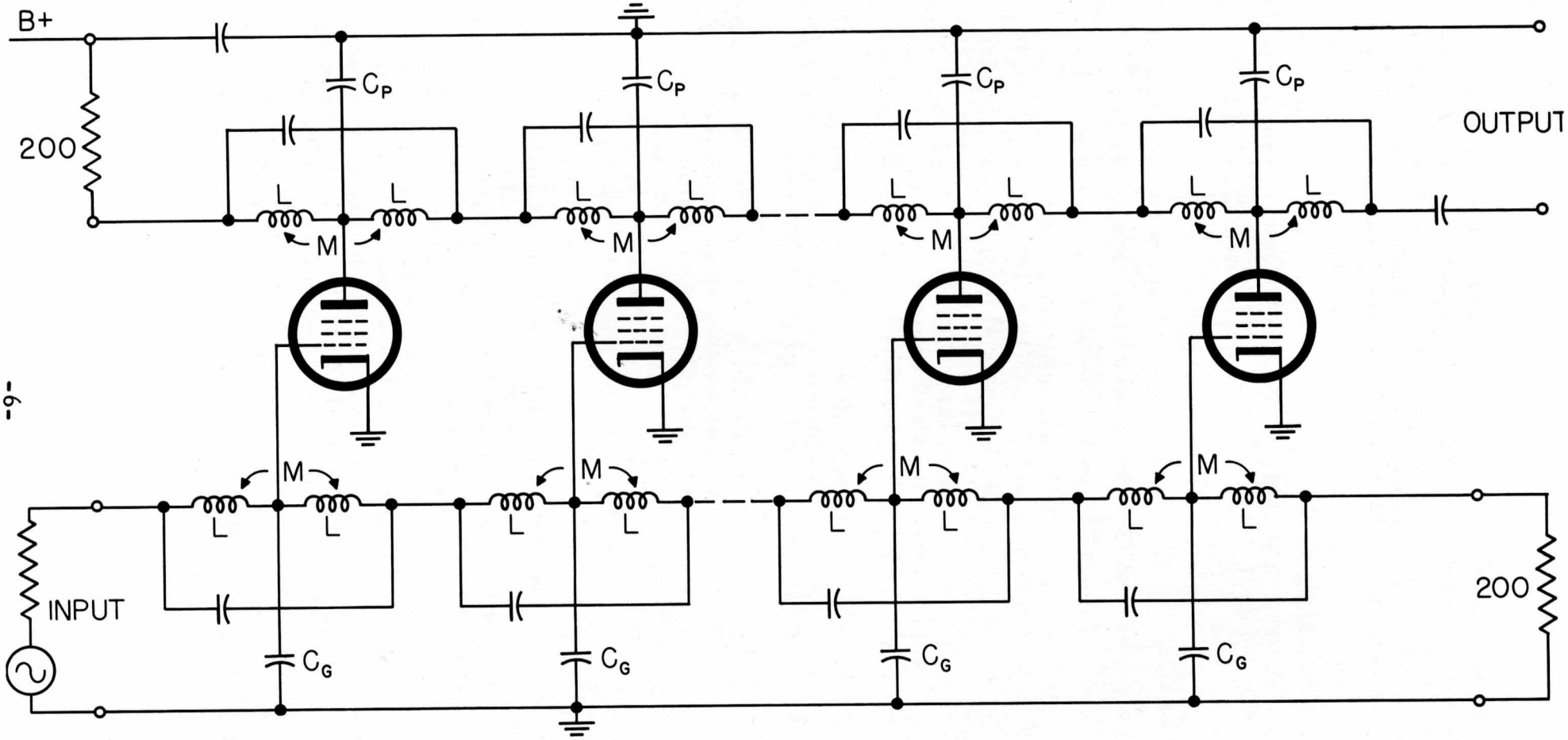

Figure 5. Basic Circuit of a Distributed Amplifier

SECTION III

THEORY OF OPERATION

3-1 DISTRIBUTED AMPLIFIER

The extremely rapid rise time of the 460B is obtained through the use of the distributed amplifier;* the operation of which is explained as follows. See Figure 5.

In the distributed amplifier, the tubes are connected at fixed intervals between two artificial transmission lines that have equal propagation velocities. A signal applied to the input terminals passes down the grid line and appears on each grid in turn. The resulting plate signal currents flow in the plate line, half in one direction and half in the other. Since the paths from the input through any tube to the output are the same length in terms of line sections traversed, the individual plate signal currents will arrive at the output termination in phase, thus adding together in the load. The plate signal currents flowing in the reverse direction are absorbed without reflection in the reverse plate line termination. The output voltage of a distributed amplifier is given by the relation

$E_o = \frac{nZp}{2}$ ip where n is the number of tubes in the stage, ip is the plate signal current, and Z_p is the plate line impedance.

The number of tubes that can be used in a single stage is limited by grid loading which occurs at high frequencies because of the increased input conductance of the amplifier tubes. This effect reduces the high frequency gain and in effect restricts the frequency range of the amplifier.

When amplifiers are cascaded, the rise time will be greater than that of a single unit in accordance with the relation:

$$T = t(n)^{1/2}$$

where: T is total rise time
t is the rise time of a single unit (2.6X10-9 sec.)
n is the number of 460 units.

In addition to the rise time of the amplifiers, the rise time of the RC combination formed by the capacitance of the deflection plates

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* Ginzton, Hewlett, et all, Distributed Amplification, Proc. IRE, Vol. 36, August, 1948

and the internal resistance of the 460B (200 ohms) should be considered.

In any case, the total rise time of any number of 460 Amplifiers in conjunction with any load may be found approximately by the following relation:

$$T = \left[nt^2 + (440C)^2 \right]^{1/2}$$

where:

n = number of 460 Amplifiers
t = rise time of one 460 = 2.6X10-9 sec.

C = total shunt capacitance on the output of the 460 in farads.
T = total rise time.

SECTION IV

MAINTENANCE

4-1 COVER REMOVAL

You will be able to slide the one-piece cover off the instrument after removing the four screws in the rear of the cover.

4-2 TUBE REPLACEMENTS

In many cases instrument malfunction can be corrected by replacing a weak or defective tube. Before making any internal adjustment or component replacement, check the tubes. Adjustments made in an attempt to compensate for a defective tube will often complicate the repair problem.

It is good practice to check tubes by substitution rather than by the use of a "tube checker". The results obtained from the "tube checker" can be misleading. Mark original tubes to insure return to the same socket. Replace only tubes proved to be weak or defective.

Any tube with corresponding standard EIA (JEDEC) characteristics can be used as a replacement.

4-3 POWER SUPPLY

The 460B power supply delivers two output voltages depending upon the setting of PULSE-LINEAR switch S1.

With S1 in the PULSE position, selenium rectifiers CR-1 and CR-2 are connected in a voltage doubler circuit. The dc output voltage between ground and the common junction of capacitor C22, filter choke L28, and fuse F2 with the line voltage set to 115 volts will be 270 $\pm$ 15 volts. Ripple voltage can be quite high without affecting instrument performance.

When switch S1 is in the LINEAR position, rectifiers CR-1 and CR-2 are connected in parallel as half-wave rectifiers. The dc output voltage between ground and the point described above will be 110 volts when the line voltage is set to 115 volts. Ripple voltage is again not critical.

Low power supply voltages are generally caused by weak selenium rectifiers, leaky filter capacitors, shorted tubes or off-value resistors.

4-4 230 VOLT OPERATION

The Model 460B can be quickly and easily converted to operate from a nominal 230 volt 50/1000 cps power source. The instrument is normally supplied with the dual primary windings of the power transformer connected in parallel for 115 volt operation. To convert for 230 volt operation, reconnect the primary windings in series as shown on the schematic diagram. The line fuse F1 must also be changed from 0.8 amp slow-blow to 0.4 amp slow-blow.

4-5 TROUBLE SHOOTING

Low gain, low output, and impaired frequency response are all directly related to tube mutual conductance and power supply output voltage. Consequently, should any of the above symptoms appear, the power supply output voltages should be checked (para. 4-3) and the tubes should be checked (para. 4-2).

Impaired frequency response, low gain, and/or excessive hum can also be caused by open or shorted coils and by defective terminating resistors or screen resistors.

If B+ fuse F2 blows, look for a B+ short, loss of bias, or a shorted 5654 tube. If a 5654 tube was responsible for the blown fuse, check the appropriate screen resistor and resistor R1 for possible damage.

Resistor R1 is made up of five 980 ohms resistors connected in parallel. Any one of these resistors could open without greatly affecting the operating voltages.

The cans of electrolytic capacitors C22, C23, and C24 are insulated from the chassis. If these capacitors are shorted to the chassis the bias voltage will also be shorted. The bias voltage is normally not more than about 10 volts and is not dangerous to personnel, but tube damage can result if this voltage is removed.

4-6 REPLACEMENT OF 200 OHM CABLE CONNECTOR

1. Cut 200 ohm cable to length desired. Trim end of cable to a point where shielding and outer insulation are even with the end of a center conductor support bead. After assembly, cable length to tip of banana plug will be approximately 1/4" shorter than trimmed cable length.

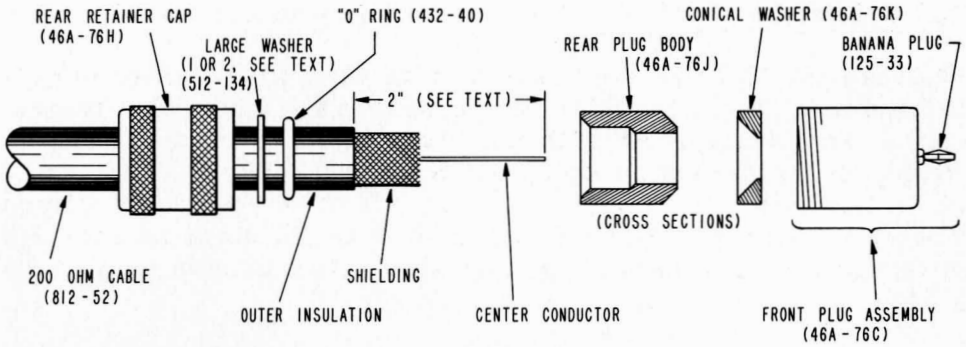


Fig. 6 Exploded View of the 46A-95B Assembly

2. Remove outer cable insulation for a distance of 2" from cable end.

3. Remove <u>three</u> support beads from center conductor. To do this, upset shielding just enough to release beads.

4. Slide the following parts over the cable shielding in order given: rear retainer cap, large washer(s), rubber "O" ring. Either one or two washers are included with the connector parts at the factory. Use all of the large 512-134 washers supplied. Purpose of additional washer is given in step 9.

5. Slide rear plug body over shielding. Hold rear plug body against end of outer insulation and cut off shielding 3/16" from beveled end of rear plug body.

6. Fan shielding out and bend back over rear plug body. Trim off any shield wire protruding beyond beveled edge.

7. Place conical washer over shielding with flat side toward end of plug.

8. Insert center conductor through hole in center of front plug assembly, slide assembly back over conical washer. Thread rear retainer cap on front plug assembly. Plug must be firmly tightened so that it cannot be rotated on

end of cable. The use of strap wrenches is recommended.

9. Measure distance between front edge of rear retainer cap and front edge of front plug assembly. This distance must not be less than 31/32". Additional washers installed as in step d will increase this distance.

10. Wrap and solder the center conductor to the base of the banana plug. Do not pull center conductor excessively tight when connecting to banana plug.

11. Resistance between outer connectors must be less than one ohm. Resistance between center connectors must be less than one ohm. Resistance between outer connectors and center connectors must be greater than 500 megohms.

4-7 TEST PROCEDURE

Testing of the 460B is a long tedious procedure, and is not often needed. However, anyone with the necessary equipment for making the several somewhat complex test set-ups can complete the procedure. The following hp instruments or their equivalent will be required.

Signal Sources	Models 212A, 608C, and 650A.
Voltmeters	Models 410B and 400D/H/L.
Oscilloscope	Model 150A.
Attenuators	Models 355A and 355B.
Miscellaneous	Cable Adapters

The complete Test Procedure is available from the hp Factory as a Service Note. Perhaps your most convenient source for these Service Notes is your local hp Representative who will be pleased to supply you with copies on request.

Your local hp Representative also maintains complete facilities and specially trained personnel to assist you with any engineering, application, test, or repair problems you may have with hp Instruments.

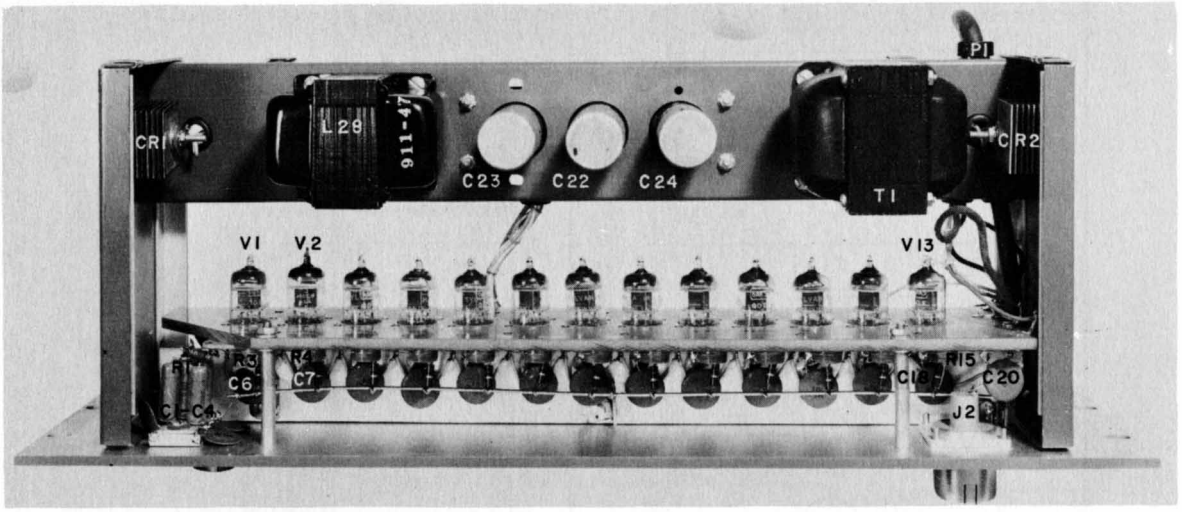


Figure 7. Top View of hp Model 460B Fast Pulse Amplifier

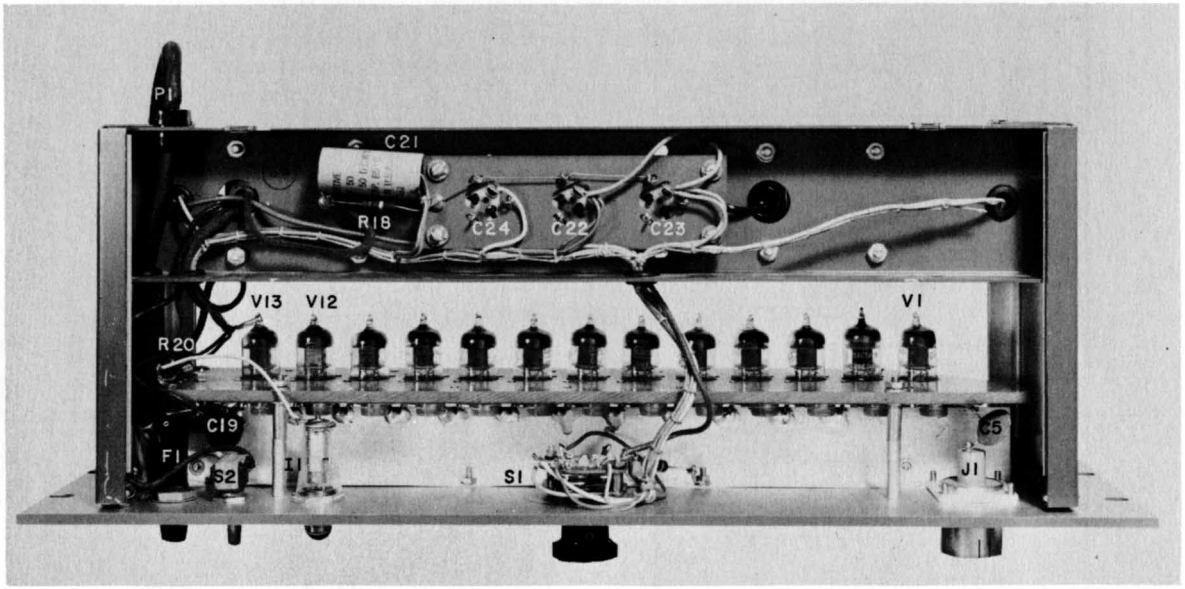
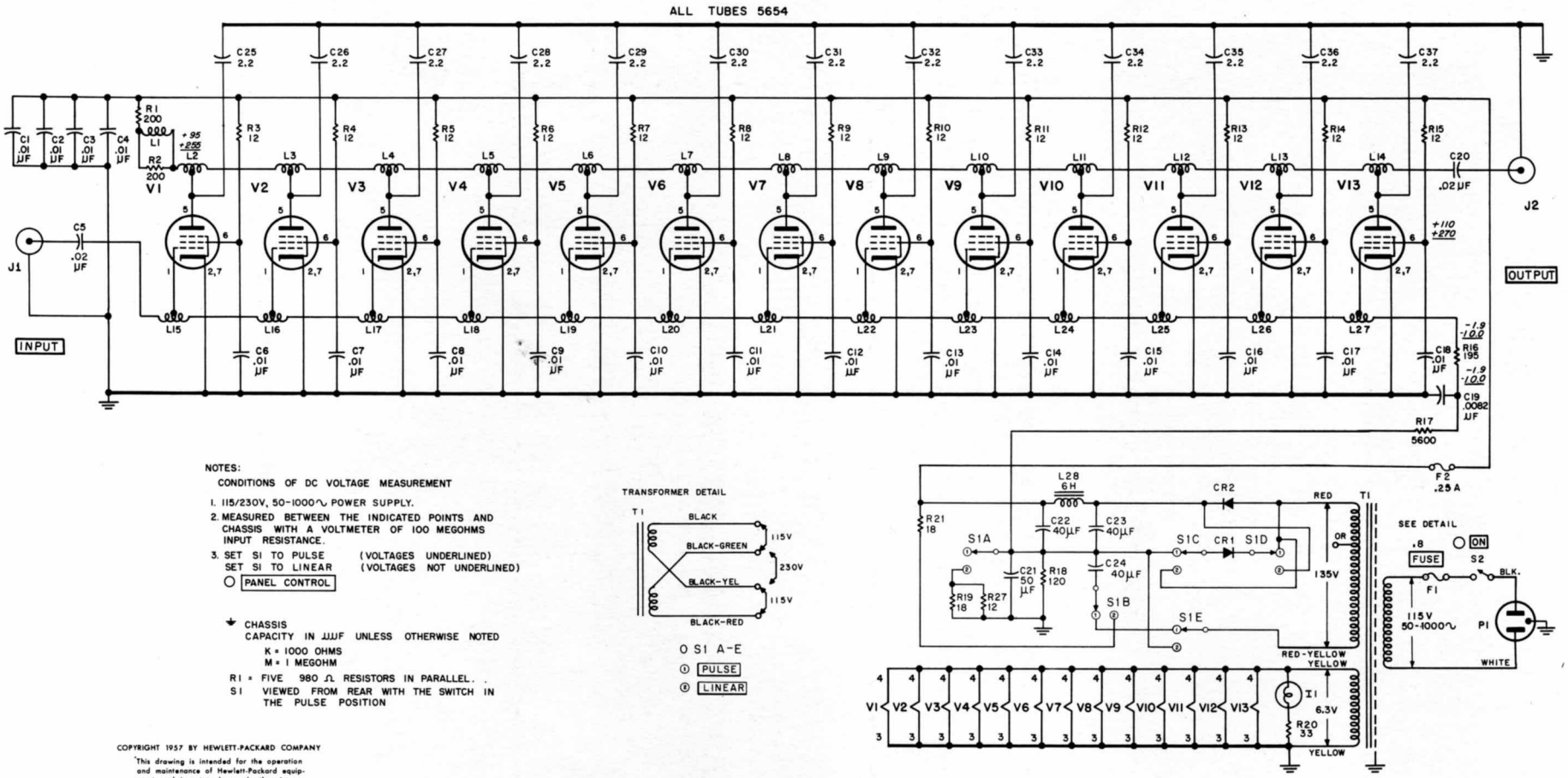


Figure 8. Bottom View of hp Model 460B Fast Pulse Amplifier



NOTES:

CONDITIONS OF DC VOLTAGE MEASUREMENT

1. 115/230V, 50-1000~ POWER SUPPLY.
2. MEASURED BETWEEN THE INDICATED POINTS AND CHASSIS WITH A VOLTMETER OF 100 MEGOHMS INPUT RESISTANCE.
3. SET S1 TO PULSE (VOLTAGES UNDERLINED)
   SET S1 TO LINEAR (VOLTAGES NOT UNDERLINED)

○ PANEL CONTROL

⏚ CHASSIS

CAPACITY IN μμF UNLESS OTHERWISE NOTED

K = 1000 OHMS

M = 1 MEGOHM

R1 = FIVE 980 Ω RESISTORS IN PARALLEL.

S1 VIEWED FROM REAR WITH THE SWITCH IN THE PULSE POSITION

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460B - 1879

MODEL 460B WIDE BAND AMPLIFIER

SECTION V

TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument model number
Serial number
-hp- stock number of part
Description of part

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#
C1 thru C4	Capacitor: fixed, ceramic, .01 µf tol. -0%, +100%, 1000 vdcw CC*	15-43	18
C5	Capacitor: fixed, ceramic disc, .02 µf tol. -0% +100%, 600 vdcw Radio Material Corp.	15-85	2
C6 thru C19	Same as C1		
C20	Same as C5		
C21	Capacitor: fixed, electrolytic, 50 µf tol. -10% +200%, 50 vdcw X*	18-50	1
C22, 23, 24	Capacitor: fixed, electrolytic, 40 µf, 450 vdcw CC*	18-40HP	3
C25 thru C37	Capacitor: fixed, titanium dioxide, 2.2 µµf ±10%, 500 vdcw DD*	15-52	13
CR1, 2	Rectifier, metallic AA*	212-73	2
F1	Fuse, cartridge: 0.8 amp, for 115V operation, slow-blow T*	211-57	1
	Fuse, cartridge: 0.4 amp, for 230V operation, slow-blow	211-56	
F2	Fuse, cartridge: 1/4 amp, regular type 3AG T*	211-6	1
I1	Lamp, incandescent: 6-8V, .15 amp, #47 N*	211-47	1
J1, J2	Jack, panel HP*	46A-76	2
L1	See R2		
L2 thru L7	Coil Assembly HP*	460B-95E	1
L8 thru L14	Coil Assembly HP*	460B-95D	1
L15 thru 20	Coil Assembly HP*	460B-95B	1
L21 thru 27	Coil Assembly HP*	460B-95C	1
L28	Reactor: 6H @ 125 ma, 240 ohms HP*	911-47	1
P1	Cable, power Elec. Cords Co.	812-56	1
R1	Resistor: fixed, precision, 980 ohms, includes 5 resistors and 4.01 µf capacitors HP*	460B-67	1
R2	Resistor: fixed, deposited carbon, 195 ohms ±1%, 1/8 W (includes L1) HP*	460B-60	1

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
R3 thru R15	Resistor: fixed, composition, 12 ohms ±10%, 1/2 W	B*	23-12	14			
R16	Resistor: fixed, deposited carbon, 195 ohms ±1%, 1/8 W	NN*	30-195	1			
R17	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W	B*	23-5600	1			
R18	Resistor: fixed, composition, 120 ohms ±10%, 2 W	B*	25-120	1			
R19	Resistor: fixed, composition, 18 ohms ±10%, 1 W	B*	24-18	2			
R20	Resistor: fixed, composition, 33 ohms ±10%, 1 W	B*	24-33	1			
R21	Same as R19						
R22	Same as R3						
S1	Switch, rotary	HP*	310-86	1			
S2	Switch, toggle: SPST	D*	310-11	1			
T1	Transformer, power	HP*	910-133	1			
V1 thru V13	Tube, electron: 5654	ZZ*	212-5654	13			
	MISCELLANEOUS						
	Adapter, type "N" to ⓗ 460, 50 ohm termination	HP*	46A-95C				
	Adapter, for ⓗ 410B to output of ⓗ 460, no termination	HP*	46A-95D				
	Adapter, for 5XP-CRT	HP*	46A-95F				
	Adapter, for Tektronix 511	HP*	46A-95G				
	Adapter, type "N" to ⓗ 460, 200 ohm termination	HP*	46A-95H				
	Adapter, type "N" to ⓗ 460, no termination	HP*	46A-95J				
	Adapter, ⓗ 410A/B ac probe to output of ⓗ 460, 200 ohm termination	HP*	46A-95K				
	Adapter, 200 ohm cable to ⓗ 150A deflection plates Note: for 150's below serial 800, also order 150A-95P	HP*	460B-95A				

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
	Cable, plug, for 200 ohm cable	HP*	46A-95B				
	Connector sleeve, joins two 46A-95B cable plugs	HP*	46A-95E				
	Deflection plate terminal board for ⓗ 150A with serial numbers below 800 when using Adapter 460B-95A	HP*	150A-95P				
	Fuseholder	T*	140-16	2			
	Jack, panel assembly, for 200 ohm connector	HP*	46A-95A				
	Knob: PULSE - LINEAR	HP*	G-74N	1			
	Patch cord, 2 feet, 200 ohm cable	HP*	46A-16A				
	Patch cord, 6 feet, 200 ohm cable	HP*	46A-16B				
	Pilot Lamp Assembly	II*	145-2	1			
	Retainer plate for panel jack	HP*	46A-76A-1				

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

MANUAL CHANGES

MODEL 460BR

FAST PULSE AMPLIFIER

Serial 2438 and above:

C22 thru C24: Change to capacitor, fixed, electrolytic, 2 sections, 20uf/section, 450 vdcw; -hp- Stock No. 18-109, Mfr., CC

I1: Change to lamp, incandescent, 6-8V, 2 pin base, GE #12; -hp- Stock No. 211-78, Mfr., N

P1: Change to power cord; -hp- Stock No. 812-106, Mfr., TT

R20: Delete

MISC: Change to lampholder -hp- Stock No. 145-25, Mfr., HP

Change jewel, pilot lamp, to -hp- Stock No. 145-23A, Mfr., HP

For instruments with Serials Prefixed: 003-, the manual for Serial 1720 and above applies with all corrections listed above.

For instruments with Serials Prefixed: 041-, include the following changes in addition to those previously listed:

C5,19: Change to capacitor, fixed, ceramic, .01uf ±20%, 100 vdcw; -hp- Stock No. 0150-0098, Mfr., RMC

C20: Change to capacitor: fixed, ceramic, .05uf ±20%, 400 vdcw; -hp- Stock No. 15-161, Mfr., NN

3/3/60
1/12/60